

WHAT IS CLAIMED IS:

1. A method of increasing an etch stability of a photoresist layer, the method comprising the steps of:
providing the photoresist layer at a thickness less than 0.25 μm , for use in vacuum ultraviolet lithography, deep ultraviolet lithography, or extreme
5 ultraviolet lithography;
exposing the photoresist layer to a plasma, the photoresist layer including exposed surfaces; and
transforming the exposed surfaces to form a shell, wherein the shell increases the etch stability of the photoresist layer.

10 2. The method of claim 1, wherein the plasma is a fluorine-based plasma.

3. The method of claim 2, wherein the plasma includes a CF_4 plasma having plasma characteristics of approximately 100 sccm flow rate, 50 mTorr chamber pressure, 400 W radio frequency (RF) power, and 50 $^{\circ}\text{C}$ lower electrode
15 temperature.

4. The method of claim 1, wherein the etch stability is increased by 20-50%.

5. The method of claim 1, wherein the transforming step includes transforming the exposed surfaces by a depth of up to approximately 50 nm.

20 6. The method of claim 1, wherein the transforming step includes at least one of decarboxylation, cross-linking, and densification of the exposed surfaces to form the hardened shell.

7. An integrated circuit fabrication process, the process comprising:

patterning a feature on a photoresist layer disposed over a substrate,
the feature patterned in accordance with a pattern provided on a mask or reticle and
a radiation at a deep ultraviolet or extreme ultraviolet lithographic wavelength;

5 developing the photoresist layer, the patterned photoresist layer
including at least one feature having a top surface and side surfaces;

 exposing the photoresist layer to a densifier;

 transforming the top surface and the side surfaces with the densifier
to form a hardened surface; and

10 etching the substrate in accordance with the transformed feature,
wherein the exposing step occurs after the developing step and before the etching
step, and an etch stability of the feature is a function of the hardened surface.

8. The process of claim 7, further comprising providing the photoresist
layer at a thickness of less than approximately 0.25 μm .

15 9. The process of claim 7, wherein the densifier is a fluorine-based
plasma.

10. The process of claim 9, wherein the exposing step includes providing
the fluorine-based plasma at operating parameters of 10-2000 sccm flow rate,
5-1000 mTorr chamber pressure, 50-2000 W RF power, and 20-80 °C lower
electrode temperature.

20 11. The process of claim 7, wherein the densifier is a flood electron
beam.

12. The process of claim 7, wherein the densifier is an ion implantation.

13. The process of claim 7, wherein the hardened surface has a depth of
2-50 nm.

14. The process of claim 7, wherein the transforming step includes at least one of decarboxylation, cross-linking, and densification of the top surface and the side surfaces to form the hardened surface.

5 15. The process of claim 7, wherein the transforming step includes fluorinating the top surface and the side surfaces.

16. A feature patterned on a photoresist layer disposed over a semiconductor substrate, the feature comprising:

exposed surfaces; and

10 a untreated region enclosed by the exposed surfaces, wherein the exposed surfaces are structurally denser than the untreated region due to at least one of a fluorination, an ion implantation, and an electron beam curing, and the feature is lithographically patterned using at least one of a deep ultraviolet lithographic wavelength, a vacuum ultraviolet lithographic wavelength, and an extreme ultraviolet lithographic wavelength or has a vertical thickness less than
15 approximately 0.25 μm .

17. The feature of claim 16, wherein a depth of the exposed surfaces is in the range of 2-50 nm.

18. The feature of claim 16, wherein the exposed surfaces comprise a top surface and side surfaces of the feature.

20 19. The feature of claim 16, wherein the exposed surfaces are structurally denser due to the fluorination, the fluorination including the feature being exposed to a fluorine-based plasma.

20. The feature of claim 19, wherein the fluorine-based plasma has operating parameters of 10-2000 sccm flow rate, 5-1000 mTorr chamber pressure,
25 50-2000 W RF power, and 20-80 °C lower electrode temperature.

21. The feature of claim 16, wherein the material comprising the photoresist layer is an organic-based photoresist material based on at least one of phenolic polymers, acrylate polymers, and alicyclic polymers.

22. The feature of claim 16, wherein the photoresist layer comprises an acrylate or alicyclic polymer and the feature is lithographically patterned using a
5 193 nm wavelength of radiation.

23. The feature of claim 16, wherein the feature is selected from a group including a conducting line, a gate for a transistor device, a contact hole, a via structure, and a trench.